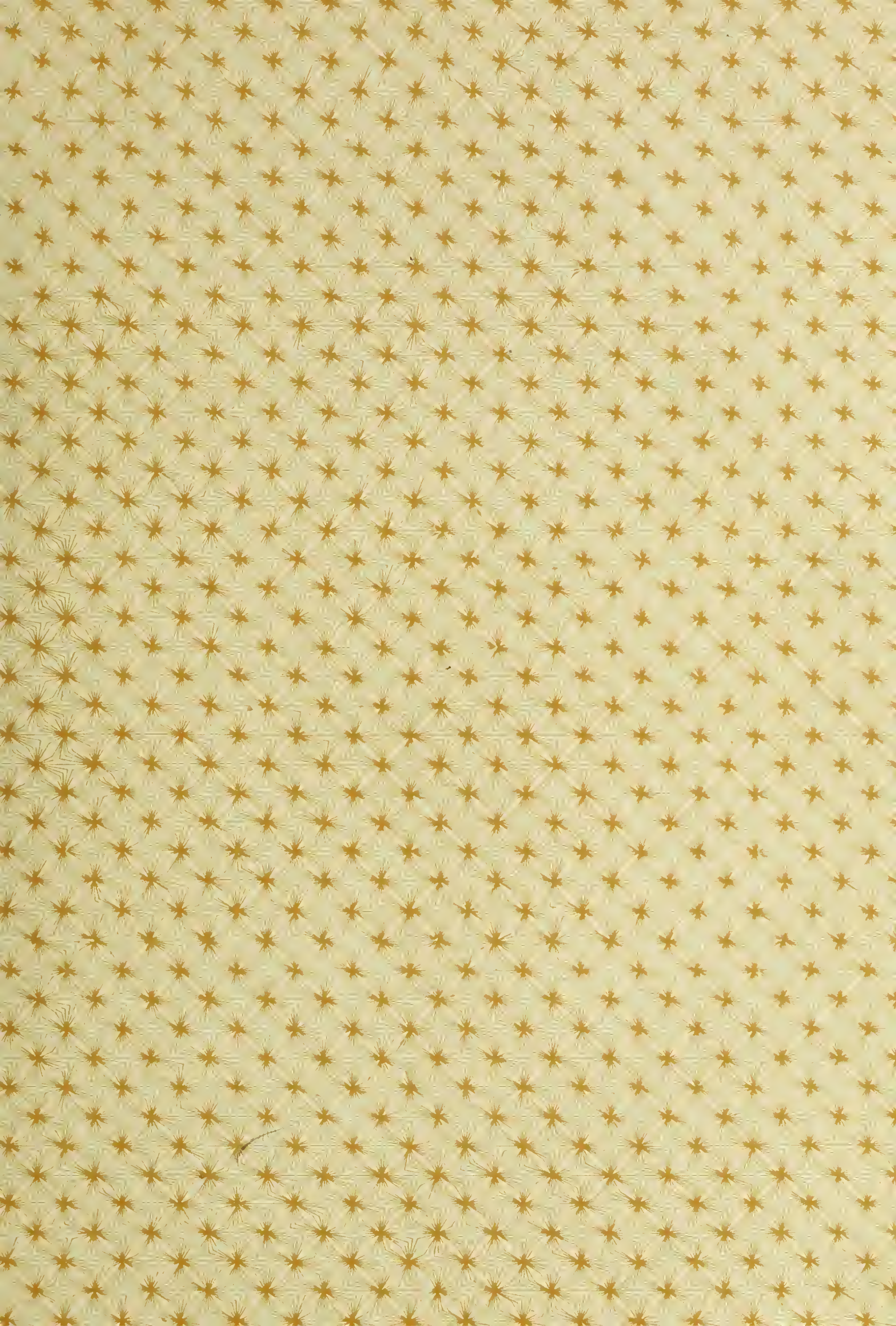
BARNHART

A Study of the Influence of Refrigeration upon the Composition of Flesh

Chemistry

BS

1906



A STUDY OF THE INFLUENCE OF REFRIGERATION UPON THE COMPOSITION OF FLESH

BY

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THESIS

FOR THE

DEGREE OF BACHELOR OF SCIENCE

IN

CHEMISTRY

IN THE
COLLEGE OF SCIENCE
OF THE
UNIVERSITY OF ILLINOIS
JUNE, 1906

UNIVERSITY OF ILLINOIS

June 1, 1906.

THIS IS TO CERTIFY THAT THE THESIS PREPARED UNDER MY SUPERVISION BY

Jesse Melangthon Barnhart

ENTITLED A Study of the Influence of Refrigeration upon the Composition of Flesh.

IS APPROVED BY ME AS FULFILLING THIS PART OF THE REQUIREMENTS FOR THE DEGREE

OF Bachelor of Science

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INTRODUCTION.

Refrigeration is the process of reducing the temperature of a heated body or substance.

The fundamental principles of refrigeration were among the first natural phenomena to be discovered by primitive science or perhaps human experience, yet strange to say, man has been slower to take advantage of them in commercial way than many later discoveries of less importance. The knowledge of the preservative action of cold upon organic substances is almost as old as humanity itself; it is known that the ancients of 2300 years ago were familiar with the rudimentary principles of artificial refrigeration yet refrigeration in its present state of commercial usefulness is the growth of the last thirty years.

The ancient Greeks[1] were the first to avail themselves of the use of ice and artificial refrigeration. Aristotle taught them to boil their drinking water and to expose it in porous vessels while yet boiling hot, in this manner causing rapid evaporation and the formation of ice in certain seasons of the year. The Egyptians, Chinese, and the natives of India also early understood and practiced the production of cold by artificial means. This manner of preserving perishable goods and food products spread westward with civilization from Greece and to Italy in the 15th century then on into France and other western European countries in the 16th century. England, it is said, did not use ice to protect their perishable products

from the ravages of heat until artificial ice was made on a commercial scale about the middle of the 19th century.

The ancient idea of refrigeration was that of insulation i. e., shielding the object to be preserved from the heat rather than actually removing the heat to cool the body as is the method used at the present time. In those days caves were dug in the hill-sides to protect goods from the heat of the sun. This was a common method of keeping articles cool at that time. Ice and snow, however, were made use of, particularly in France. When ice was used it was always stored in these subterranean store-houses in small pieces instread of large cakes. It was left for the Yankee to store ice in cakes in ice-houses above the surface of the ground and protect it by saw-dust from the air and the heat of summer.

The first serious attempt[2] to produce artificial cold by means of chemicals was made in Italy in 1550. No ice was made in this case but a refrigerating solution was the result which was used principally to cool wine, water and other drinks.

The use of ice to preserve perishable goods began in New York and Boston about 1805. The practice grew steadily and by 1825 ice was used in all the principal cities in the East especially those along the Atlantic sea-board. No marked growth in the refrigeration industry took place, however, until the Civil war. It was the War of the Rebellion that created a demand for refrigerated products and showed the United States the value and necessity of refrigeration in this country. Americans were among the first to recognize the value of re-

frigeration and did much to develop the industry which has done so much toward the development of the country.

The real cause for the wonderful development of the ice and refrigerating industry in America is probably the low altitudes and the consequent dense humidity of the atmosphere that is so destructive to all kinds of perishable products. This has made the use of refrigeratory processes indispensible in the United States.

Up to this time the ice used for refrigerating purposes was obtained from nature. Nothing of any commercial importance had been accomplished in the way of production of ice by artificial means or the production of cold by chemical and meachnical processes.

[3]In 1858-60 Ferdinand P. E. Carré: patented the beginning of the now famous "absorption system". In 1869 Reace perfected this system and so materially benefited the Carré machine that it became the first to obtain commercial importance in the United States where it did much to establish the frozen meat trade throughout the world. The manufacture of ice[4] first attained commercial importance at New Orleans in 1866 when a plant was built and successfully operated there. From that time the refrigeration industry has come into commercial and imdustrial importance by leaps and bounds.

Few people realize the number and output of the cold storage plants of the world. In 1905[5] the total output of the world's freezing works was approximately 367,550 tons; this was against 305,586 tons in 1904 and 324,268 tons in 1903. In

1902 there were 130 cold stores and ice factories in Great Britian. The number of firms making refrigerating machinery, ammonia, carbonic anhydride, and other refrigerating media, proprietors of cold stores, importers or manufacturers of ice were nearly 1,300. On the Continent there were nearly 4,400 firms interested in refrigeration; in American 5,600 and in China, Japan, Java, India, Ceylon, Malay Peninsula, Philippine Islands, Siam, Africa, Austrialia, New Zealand, Egypt, and Algeria, about 1,500. This makes a grand total of 12,800 and does not include the many butchers, fishmongers, hotel proprietors and others who have small cold stores cooled by refrigerating machinery and by ice.

The ice making capacity of all the refrigerating machines built in the United States,[7] its possessions, and Canada up to and including the year 1905 was 75,590 tons per day or nearly 15,118,000 tons annually. The state of New York ranked first in the number of machins and tons of refrigeration produced, Pennsylvania, Indiana, Illinois, third. The city of Chicago alone had 367 ice and refrigerating machines with a capacity of 675 tons daily. St. Louis had 162 machines making ice with a capacity of 2,218 tons daily. In cu. ft. of cold storage capacity Missouri was first, Illinois, second.

Swift and Company of Chicago, Ill.[8] own the largest single unit of refrigerating machinery in the world with 750 tons capacity per day. The largest single ice making plant is the Jacob Ruppert plant in New York City, with a capacity of 965 tons per day. Baltimore has a 600 ton plant and Philadelphia a 400 ton plant.

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[9]The Anheuser-Busch Brewering Association in St. Louis is the largest single producer of ice in the world. Their daily capacity is 1,190 tons. The American Ice Company is the largest ice company in the world. They operate 3,000 wagons, 4,000 horses, and sell about 4,000,000 tons of ice annually or about 1/5 the entire output of ice in the United States.

In addition to cold storage plants, refrigerating cars and steamers are employed to preserve perishable goods in transportation to distant markets. The refrigerator car and steamer have made it possible to carry safely every kind of perishable food products to all parts of the world.

In 1868 the first refrigerator car was built[10] and in September of the following year the first cargo of fresh beef was shipped from Chicago to Boston. In 1880 the Strathleven,[11] one of the first cold storage steamers, brought, successfully, the first carge of frozen meat from Australia to England. An earlier attempt by these two countries to ship fresh meat by sea was made in 1873 but resulted in failure. In 1875 some shipments of frozen meat was made from America to England. In 1905 there were 75,000 refrigerator and icing cars in operation in the United States and in the same year 560 refrigerator steamers carried the frozen products of the world.

According to Pastoralist's Review during the first half of the season of 1905, 359,000 carcasses of mutton, 870,000 carcasses of lamb, and 17,500 quarters of beef were sent to England from Australia in addition to 319,000 carcasses of

mutton, 16,000 carcasses of lamb and 116,000 quarters of beef that were shipped to South Africa. The exports from New Zealand, a country very prominent in the meat trade, during the same period, amounted to 920,000 frozen sheep, 1,443,000 lambs and 51,000 quarters of beef. Argentine Republic, during the same period also, exported 1,711,000 frozen sheep, 31,000 lambs and 1,065,000 quarters of beef. In August 1905, it was estimated that 550,000-600,000 tons of beef, mutton and lamb would have to be imported into Great Britian to supply the markets.

In 1904 Great Britian paid £17,669,618 for poultry and eggs[13] of which £8,000,000 worth were shipped from foreign countries, the importation of which was made possible by refrigeration. In the same year 1,720,905 tubs of butter, 56 lbs. each, were imported from Australia.

Turning to the Unites States, the Bureau of statistics reports the exports of fresh and chilled beef from the United States in 1905 as 254,360,198 lbs. valued at $23,246,792; in 1904 as 262,328,760 lbs. at $24,142,398 and in 1903 as 293, 401,843 lbs, valued at $26,702,858.[12] In the same year the United States exported 3,352,187 dozens of eggs valued at $731,344 as against 2,355,558 dozen in 1904 valued at $516,268 and in 1903, 1,456,342 dozen valued at $316,211.

Refrigeration as a method for preserving food is much used in the preservation of foods of all kinds but it has no doubt received greater application in the case of flesh than other varieties of food.

To the causual observer it would seem that refrigeration costs more than it is worth. Notwithstanding the immense amount of capital invested in cold storage plants, ice houses, refrigerator cars and steamers, this outlay of money is more than justified by the wider market produced and, in many cases, by actual improvement in the quality and taste of the food. Refrigeration prevents loss of food products due to overproduction and lengthens the slaughtering season, in the case of meats, thus creating a more stable equilibrium in prices and increasing the output.

The freshness of flesh preserved in this way is pretty well established. When it is frozen and kept in that condition meat will keep indefinitely. In the Museum of the Imperical Academy of Science at St. Petersburg are the skeleton and stuffed hide of a large mammoth[14] that was found in north eastern Siberia in 1901. The carcass was found encased in a glacier and in such a perfect state of preservation that the arteries and veins were still full of coagulated blood. Undigested food was found in the stomach, between the teeth, and on the tongue. Even the eyes were full and intact showing the remarkable preservative effects of the low temperature. As the mammoth was of an extinct species of elephant it must have been embedded in the ice hundreds and perhaps thousands of years.

Another extreme example[15] of the preservative effects of cold is the case of the body of the Norwegian sailor that was found in the Bering Sea imbedded in a cake of ice. The corpse, although it had been in the ice for five years, was so

thoroughly preserved that the features of the man did not show the slightest indications of change.

A number of years ago, a New York cold storage company made an experiment hoping to prove or disprove that cold would preserve flesh[16] for an indefinite length of time. A turkey was placed in a refrigerator room and allowed to remain there in a frozen condition for ten years. At the end of this time it was removed and on examination was found to be in an excellent state of preservation, An expert chef was engaged to prepare the fowl for a small banquet that was held in honor of the event. The cooked meat had the appearance of cooked fresh meat but it was sadly lacking in flavor being tasteless as a piece of dry wood.

The importance of refrigeration to the producer, the dealer, and the consumer must not be overlooked.

Cold storage means much to the producer. It prevents waste due to inability tohandle goods in season and it also does away with losses due to the spoiling of an over-production. Refrigeration thereby increases his output and helps to minimize the cost of production. Before cold storage came into use the slaughtering season of animals was restricted tothe winter months whereas now slaughtering goes on the year round. In the case of fisheries, the catching of fish is limited to a few weeks in the year when a large force of men formerly had to work day and night to can enough fish to supply the demand before they should spoil. As it is today they are frozen and the canning process allowed to proceed at a more convenient

rate.

From the dealer's point of view refrigeration is just as valuable. It relieves him of all the old dangers of loss through tainted and spoiled food. In some cases refrigeration actually enhances the value of his goods. Beef when maintained at a temperature slightly above freezing goes through a change known as ripening which up to a certain limit improves the taste and the price of the meat correspondingly.

The consumer perhaps derives more benefit from cold storage than both classes. It was his wants and demands that made refrigeration a necessity and made possible its successful maintenance. Cold storage increases the variety of his food supply and diminishes its cost in that it lowers the cost of production. It makes, in many cases, his food more palatable and in some cases more beneficial to the health. In addition it protects him from the dangers that may arise from famine in the years of failure by preserving the overproduction of years of abundant yields.

Preservation of food, especially meat, by means of refrigeration is displacing preservation by chemicals and other forms of preservatives. At one time, not many years ago, there existed a strong prejudice, expecially in Europe, against refrigerated meats. This is rapidly disappearing. Frozen meats are now looked upon with more favor than canned meats. Of late years the production of canned meats, especially beef, has fallen off. In 1890 the United States produced[17] 133,428,456 lbs. of canned beef, in 1900, 123,249,021 lbs. and exported in 1890

82,638,507 lbs. and in 1900 55,553,745 lbs. The "Embalmed Beef Scandal" during the Spanish-American ~~was~~ gained ground for frozen meats at the expense of the canned article.

The chief objection to the preservation of flesh by refrigeratory methods is the alleged development of ptomains in frozen meats. Very little investigation of any value has been done along this line of work. It is thought, however, that cold storage meats lose their vitality in refrigeration to some extent and when exposed to the outside air, decay more rapidly than the freshly slaughtered meats. It is quite possible that frozen meats may develop ptomains upon exposure more readily than fresh meats but it is improbable that the ptomains are developed during refrigeration and exist before the meat commences to deteriorate upon exposure.

PRINCIPLES OF MECHANICAL REFRIGERATION.[18]

Cold storage warehouses are maintained at the desired low temperature by cold produced by the evaporation of some liquified gas. It is a well known fact that liquids upon evaporation absorb heat. This principle of physics is made use of in mechanical refrigeratory processes. The refrigerating gases in common use are anyhdrous ammonia, carbonic acid and sulphurous acid. Two methods, known respectively as the compression and absorption methods are in general usage.

In the compression system the refrigerating gas is compressed in a machine called the compressor, hence the name of the system. In the process of compression heat is generated but the gas is cooled on conduction into pipes or condensers cooled by water where at the same time it becomes liquified.

The liquid gas is then passed into the refrigerator cooling coils when the evaporation of the liquid taken place, the necessary heat being absorbed from the surrounding atmosphere. The process completed, the gas is conducted back to the compressor and the operation repeated over and over again making the process of refrigeration one of cylic nature.

In the absorption system the gas for the purpose is obtained by heating a strong aqeous solution of ammonia in a still and driving off the ammonia gas. The gas is condensed and passed into the refrigerating coils where it evaporates as in the compression system. After evaporation the gas is absorbed by a dilute solution of ammonia whereupon the resulting strong solution is pumped back into the still and the operation repeated, this method also being a cyclic process.

The above systems are used for the production of cold rather than for its application. Three general methods are used for the application of cold in cold storage roosm-the direct expansion, the brine circulating, and the air circulating systems.

In the direct expansion system the liquified gas evaporates in the refrigerating coils which are located in the cold storage room. The heat in the room is absorbed directly by the evaporation of the liquid gas.

In the brine circulating system the liquified gas instead of evaporating in coils in the refrigerator room is evaporated in pipes surrounded by brine. The brine, which is thereby reduced to a low temperature, is conducted by pipes into the cold storage room where it absorbs the heat of the surround-

ing atmosphere.

In the air circulating system, or the direct system, as it is sometimes called, the air in a well insulated room is cooled by the direct expansion of the brine circulating system after which it is forced through ducts into the refrigerator rooms. In all these systems the cooling medium, gas, brine, or air as the case may be, is used over and over again.

[19]Cold storage rooms are usually kept at a temperature of about 34°F.; chilling rooms at 30°F. and freezing rooms from 0° or lower to 10°F.

In considering the best temperature at which meat should be kept the length of time that it is to remain in the cold storage room should be taken into account. [20]For the preserving of meat for a comparatively short time a temperature of 30-40°F. is the best as most varieties of meat, if allowed to freeze, are thought to be more or less injured by the rupturing of the vesicles or cells of which the meat is composed.[21] When it is necessary to keep meat longer than three weeks it should be frozen otherwise a slight decomposition takes place and the meat becomes deteriorated. The temperature for unfrozen meat need not be lower than 25°F. but it should not go above 30°F. If meat is to be kept for any length of time it should be frozen. In freezing it the process should be done gradually to avoid bursting the cells of the flesh. For the same reason the thawing-out process should be carried on slowly. When frozen meat should be maintained at a temperature at least as low as 15°F.

HISTORICAL REVIEW.

As far as the writer has been able to find out, few investigations have been made upon the composition of refrigerated meats. The experiments of P. Grassman in 1892 and 1894[22] A Gautier in 1897,[23] and Rideal[24] in the same year seems to be the extent of the work done along this line.

A. Gautier's work, a comparative study of the composition of fresh and refrigerated meats, as far as known is the most extensive investigation made up to the present time. His experiments were made upon beef and mutton, the fresh meat being the flesh of French animals while the refrigerated meat was that of animals from Argentine Republic that had been frozen 5-6 months. The object of his experiments was to investigate the validity of the objections to refrigerated meats, then current, such as their disagreeablity to taste, indigestibility and small nutritive value as compared with fresh meats.

The work of Rideal was done for a British firm to ascertain the influence of freezing upon the digestibility of meat for the purpose of throwing some light upon the relative value of fresh and refrigerated beef as food.

The literature containing the other mentioned investigations was not available.

OBJECT OF THIS INVESTIGATION.

The object of this investigation was to make a comparative study of the composition of fresh and refrigerated flesh, especially beef. For this purpose analyses were made of

a number of cuts of two different animals.

CONDITIONS OF THE EXPERIMENTS.

The first animal was killed November 17, 1905. One half was analysed fresh while the remaining half was allowed to hang in cold storage at a temperature just above the freezing point of water for a period of 19 days when it was taken down and determinations exactly similiar to those made upon the fresh beef, were made upon the refrigerated portion. The cuts of this animal that were examined were the rib, plate, chuck, round, and loin cuts.

The second animal was slaughtered December 19. In this case the entire carcass was allowed to remain in cold storage, (at the same temperature as in the first case) one week when the first half was taken out and analysed. Only the loin and round cuts of this animal were studied. The remaining half was permitted to hang for 45 days when the corresponding cuts were analysed. The methods used and the determinations made in the analysis of this meat were exactly the same as those in the first case. The actual time of refrigeration of the second animal was the only variation in the experiment, the second beef being allowed to hang in the refrigerating room over twice as long as the first one. In each case the meat appeared in as perfect state of preservation as the fresh meat.

METHODS OF ANALYSIS.

The analytical methods used in the examination of the different samples of meat were essentially the same as given

in Bulletin No. 162[25] and Chemistry of Flesh (second paper).[26]

The meat in each case was cut into small pieces and passed through a sausage mill twice. After each grinding the mill was cleaned and the meat thoroughly mixed. Following the second cleaning and mixing, a disc with small openings was substituted for the first one. A portion of the meat was passed through the chopper a third time, mixed thoroughly again and placed in a Mason jar provided with a closely fitting cover to prevent loss of moisture by evaporation.

By direct analysis the percentage of water, total nitrogen, fat, ash, and total phosphorus were obtained while by analysis of the cold water extract of the meats the percentage of soluble ash, soluble nitrogen, soluble nitrogen coagulated by heat, albumose mitrogen, peptone nitrogen, total soluble phosphorus, soluble inorganic phosphorus, and total soluble matter were obtained. From this data the composition of the flesh is expressed directly or by calculation as soluble coaggulable proteid, albumose, peptone, total soluble proteid, insoluble proteid, total proteid, nitrogenous extractives, non-nitrogenous extractives, total orgainc extractives, fat, soluble ash, insoluble ash, total ash, soluble inorganic phosphorus, total soluble phosphorus, insoluble phosphorus, and total phosphorus.

METHODS OF DIRECT ANALYSIS.

TOTAL NITROGEN:-The Sherman-Kjeldahl method was used. 1.5-to 2.0 grams of meat were taken for each analysis. The sample was treated in a Kjeldadl flask with 25 CC of $H_2SO_4$and

.7 grams of mercury; heated until frothing ceased and 10 to 15 grams of powdered K_2SO_4 added. After clearing the liquid was heated 1 1/2 hours longer when oxidation was regarded as complete. The nitrogen compounds of the flesh were thus decomposed and the nitrogen converted into $(NH_4)_2SO_4$. The solution of this sulphate was treated with alkali, distilled and the ammonia liberated, collected in a known quantity of standard HCl solution.

ASH:-From 1.5 to 2.0 grams of meat were weighed into tared crucibles. The meat was then heated in a boiling water-oven for 3 to 4 hours after which it was ignited in the muffle, cooled and the ash weighed.

MOISTURE:- 1.5 to 1.8 grams of meat were weighed into moisture tubes one end of which was covered with a piece of ordinary quantitative filter paper strengthened by a covering of hardened filter paper. In the analysis of fat meats, plugs of fat free paper were placed in the tubes. The moisture samples were heated for 12 to 15 hours in a boiling water-oven when they were transferred to a glycerine bath and heated at 104°C. for periods of 3 hours in a current of hydrogen until constant in weight.

FAT:-The residues from the moisture determinations were extracted with anhydrous ether with a Soxhlet apparatus for 24 hours. The samples were then freed from ether and ground with ignited sand after which the extraction was continued for 12 hours longer. The ether was then evaporated off and the residues of fat dried in an air bath at 103°C. until constant in weight.

TOTAL PHOSPHORUS (gravimetric method):- For this determination approximately 5.0 grams of meat were weighed into a Kjeldahl flask, treated with 20 CC. concentrated H_2SO_4 ~~and~~ and digested. When well charred 5 to 10 grams of crystallized NH_4NO_3were added to complete the oxidation which was indicated by the liquid becoming colorless. The clear solution was transferred to a beaker, neutralized with NH_4OH , 5 grams of NH_4NO_3 added and at a temperature of 60°C., the phosphoric acid was precipitated with 100 CC. of acid molybdic solution. After standing for 1 1/2 to 2 hours, the liquid was filtered off and the yellow precipitate washed with NH_4NO_3 solution. The ammonium phospho-molybdate precipitate was then dissolved in dilute ammonia, the solution neutralized with HCl and the phosphorus precipitated in the usual way with magnesia mixture.

All of these determinations were madein triplicate.

PREPARATION OF COLD WATER EXTRACT.

About 100 grams of the thoroughly mixed sample of meat were weighed out in two lots of approximately 50 grams each and each lot divided among 9 beakers, requiring 18 beakers for one extract. The meat in each beaker was moistened with a little ammonia free distilled water, all lumps broken up and the flesh stirred into a paste. 50 cc. of the distilled water were then added to each portion and stirred for about 15 minutes. After allowing the residue to settle, the partial extract in each beaker was decanted through filters into 250 cc. Florence flasks. 25 cc. of water were then added to the residue, stirred for 8 to 10 minutes, the residues allowed to settle again and the liquid decanted as before. The process of extrac-

tion was continued, using 25 cc. of water each time, until the volume of the liquid in each flask amounted to 230 cc. when the residues were transferred to their respective filters and washed thoroughly. The filtrates were then poured into a large flask and after rinsing each flask twice with distilled water the extract was made up to 5 liters.

ANALYSIS OF COLD WATER EXTRACTS.

TOTAL SOLIDS AND ASH:- Two portions of 100 cc. each of the extract were evaporated to dryness in weighed platnum dishes. The residues were dried in a water-oven for periods of one hour until constant in weight. The residues were then ignited over a free flame until constant in weight.

TOTAL NITROGEN:- Three 100 cc. portions of the extract were measured into Kjehdahl flasks and the nitrogen determined by the same method employed in the direct analysis for nitrogen. In this case, however, more dilute standard solutions (approximately N/15) were used in the titrations.

COAGULABLE NITROGEN:- 200 cc. portions in triplicate were measured out in beakers, evaporated upon a water bath to 40 cc. and neutralized when cold to 1/2 the acidity of the solution with N/10 NAOH. After heating 15 minutes the hot solutions were filtered through nitrogen free filters and the coagula washed with hot water. The filters and contents were placed in Kjeldahl flasks and the coagula remaining in the beakers carefully transferred to the flask with hot sulphuric acid. The nitrogen was then determined in the usual way.

NITROGEN AS ALBUMOSES:- The filtrates from the coag-

ulable nitrogen were evaporated to 20 cc., cooled, 1cc. H_2SO_4 (50 0/0 solution) added, diluted to 30 cc. and then completely saturated with crystallized $ZnSO_4$. After treating with $ZnSO_4$, the solution was heated on the water bath until the salt was dissolved, stirring at the same time to prevent the $ZnSO_4$,from caking on the bottom of the beaker. The solutions were allowed to stand at least 12 hours when they were filtered through nitrogen free filters. The filters, precipitates, and beakers were washed with a saturated solution of $ZnSO_4$ which was slightly acidified with H_2SO_4 . The precipitates were carefully transfered to Kjeldahl flasks with hot water and H_2SO_4 and the nitrogen determined in the usual manner.

NITROGEN AS PEPTONES:- Three 200 cc. portions of the extract were measured into beakers and the operation carried on exactly in the same manner as for the determination of coagulable nitrogen up to and including the filtration of the colution. At this point the filtrate from the coagula was collected in 100 cc. measuring flasks. After cooling, the filtrate was treated with 5 cc. of a 20 0/0 solution of NaCl and 5 cc. of a 12 0/0 solution of tannin, mixed thoroughly and the precipitate allowed to settle after which the clear liquid was tested with a few drops of tannin solution. If precipitation was complete the solution diluted to 110 cc. and allowed to stand for 24 hours, when it was filtered through dry filters and 100 cc. of the filtrate transferred to Kjeldahl flask and the nitrogen determined by the usual method. The nitrogen in form of peptone was obtained by difference, i. e. it is equal to the coagulable

nitrogen and the albumose nitrogen substracted from the nitrogen precipitated by tannin and salt.

TOTAL PHOSPHORUS:- Three 500 cc. portions of the extract were measured into Kjeldahl flasks, each treated with 20 cc. of concentrated H_2SO_4 and the process continued as given for the total phosphorus in the direct analysis.

INORGANIC PHOSPHORUS:- 500 cc. lots in triplicate were evaporated in beakers to 75 cc. While hot the solutions were filtered from the coagulated proteid which was washed thoroughly with hot water. After neutralizing the filtrates, if necessary, with dilute NH_4OH , 5 to 10 grams of NH_4NO_3were added to each and heated to 60°C. Three cc. of 1.20 HNO_3were then added and the inorganic phosphorus precipitated with 75 cc. of neutral molybdic solution. The solutions were kept at this temperature for 15 minutes and stirred well to facilitate precipitation. After standing for two hours the solutions were filtered and the precipitates thoroughly washed with NH_4NO_3 wash water. The precipitates were then dissolved in ammonia and reprecipitated with 50 cc. of acid milybdic solution under the usual conditions and the determination continued as in the method given for total phosphorus in the direct anlysis.

DISCUSSION OF RESULTS.

In this paper the analytical data is given in the following four tables. Table No. 1 gives, in percentages of fresh substance, the total constituents of the meat, omitting the detailed analysis. Table No. II gives the composition of the beef in complete detail in terms of the fresh substance while tables Nos. III and IV give the results of analysis in percents of water free and water and fat free substances respectively. Water and fat when considered in the percentage composition of flesh give use to discrepancies which may lead to erroneous conclusions in comparing the varying amounts of the different constituents of flesh. For this reason the comparisons here given are made principally upon the water and fat free basis.

For convenience of interpretation of results the analysis of the fresh cut is given first and in each case followed beneath by the data for the corresponding refrigerated cut. Also, the cuts are grouped in two groups for each animal, the first group containing the cuts of the fore quarter and the second those of the hind quarter. This plan of tabulation is observed throughout the entire series of tables.

Table I (See page 22) is intended to show that the fresh cuts and their corresponding refrigerated cuts have the same composition as far as the total amount of each constituent is concerned. This is true within the limits of error for the methods of analysis employed except in the case of water and fat.

Table No. I.

Chemical Composition of Raw Beef.

A Comparison of Fresh and Refrigerated Cuts.

Total Constituents.

Fresh substance.

Table I.

Lab. No.	Cut of Meat	Condition	Water %	Protein N x 6.25 %	Fat %	Ash %	Total N. %	Total P. %
1st animal fore quarter								
1927	rib	Fresh.	65.92	19.06	14.46	.91	3.05	.19
1957	"	Refrig.	64.41	19.06	15.90	.88	3.05	.19
1929	plate	Fresh	61.66	17.94	19.56	.85	2.87	.18
1959	"	Refrig.	59.98	17.38	21.53	.75	2.78	.17
1930	chuck	Fresh	66.20	19.44	14.53	.95	3.11	.21
1960	"	Refrig.	67.87	18.88	12.03	.91	3.02	.20
	Average ③	Fresh	64.59	18.81	16.18	.90	3.01	.20
	" ③	Refrig.	64.09	18.44	16.49	.95	2.95	.19
hind quarter								
1924	Round	Fresh	71.29	21.06	6.32	1.04	3.37	.23
1954	"	Refrig.	70.19	20.44	8.20	.98	3.27	.23
1926	loin	Fresh	67.26	19.81	12.66	.84	3.17	.21
1956	"	Refrig.	67.27	19.75	11.99	.95	3.16	.22
	Average ②	Fresh	69.28	20.44	9.49	.94	3.27	.22
	" ②	Refrig.	68.73	20.10	10.20	.97	3.22	.22
2nd animal fore quarter								
1973	chuck	Fresh	70.71	18.78	8.76	.98	3.10	.21
1993	"	Refrig.	71.69	20.63	6.69	.95	3.30	.23
hind quarter.								
1969	loin	Fresh	71.12	19.44	7.59	.99	3.11	.24
1988	"	Refrig.	70.50	20.88	7.78	1.04	3.34	.22

Table No. II.

Chemical Composition of Raw Beef.

A comparison of Fresh and Refrigerated Cuts.

Fresh substance.

Table II.

Lab. No.	Cut	Description	Water	Dry Substance			Protein						Organic Extractives			Fat	Ash			Nitrogen					Phosphorus				
							Soluble													Soluble					Soluble				
				Soluble	Insoluble	Total	Coagulable	Albumoses	Peptones	Total	Insoluble	Total	Nitrogenous	Non-nitrogenous	Total		Soluble	Insoluble	Total	Proteid	Non-proteid	Total	Insoluble	Total	Inorganic	Organic	Total	Insoluble	Total
				%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%
1st animal fore quarter																													
1927	rib	fresh	65.92	4.77	29.70	34.47	1.77	.15	.03	1.95	15.10	17.05	.99	1.06	2.05	14.46	.77	.14	.91	312	317	629	2.416	3.045	.097	.042	.139	.055	.194
1957	"	refrig	64.41	4.85	31.17	36.02	1.88	.27	-.01	2.14	15.12	17.26	.89	1.09	1.98	15.90	.73	.15	.88	.343	.286	629	2.418	3.047	.105	.043	.148	.046	.194
1929	plate	fresh	61.66	4.24	34.23	38.47	1.45	.17	-.17	1.62	14.55	16.17	.88	1.01	1.89	19.56	.74	.11	.85	259	.282	541	2.328	2.869	.078	.052	.130	.053	.183
1959	"	refrig	59.98	3.81	36.06	39.87	1.37	.20	-.14	1.57	14.33	15.90	.74	.95	1.69	21.53	.55	.20	.75	.250	.237	.487	2.294	2.781	.096	.029	.125	.044	.169
1930	chuck	fresh	66.20	4.65	30.25	34.90	1.68	.20	.15	2.03	15.56	17.59	.93	.90	1.83	14.53	.79	.16	.95	324	.299	.623	2.491	3.114	.107	.030	.137	.069	.206
1960	"	refrig	67.87	4.70	27.27	31.97	1.67	.36	-14	2.02	15.13	17.15	.85	1.03	1.88	12.03	.80	.11	.91	324	.271	595	2420	3.015	.115	.025	.140	.059	.199
average (3)		fresh	64.59	4.55	31.39	35.94	1.63	.17	.07	1.87	15.07	16.94	.93	.99	1.92	16.18	.77	.13	.90	.298	.300	.598	2.411	3.009	.094	.041	.13[illegible]	.059	.194
average (3)		refrig	64.09	4.45	31.50	35.95	1.64	.28	-.01	1.91	14.86	16.77	.83	1.02	1.85	16.49	.69	.16	.85	.306	.264	.570	2.378	2.948	.105	.033	.138	.049	.187
hind quarter																													
1924	round	fresh	71.29	5.77	22.67	28.44	2.63	.15	-35	2.78	16.18	18.96	1.06	1.06	2.12	6.32	.87	.17	1.04	445	341	.786	2.588	3.374	098	.050	.148	.082	.230
1954	"	refrig	70.19	5.72	24.11	29.83	2.04	.22	.02	2.29	15.85	18.14	1.14	1.37	2.51	8.20	.92	.06	.98	.366	.366	.732	2.537	3.269	.118	.052	.170	.055	.225
1926	loin	fresh	67.26	5.57	27.96	33.53	2.06	.19	.02	2.27	15.26	17.53	1.15	1.36	2.50	12.66	.80	.04	.84	.363	.368	.731	2442	3.173	.096	.045	.141	.072	.213
1956	"	refrig	67.27	5.33	27.61	32.74	1.90	.21	.01	2.12	15.52	17.64	1.07	1.29	2.36	11.99	.85	.10	.95	339	342	.681	2.483	3.164	.110	.044	.154	.061	.215
average (2)			69.28	5.67	25.32	30.99	2.35	.17	.01	2.53	15.72	18.25	1.11	1.20	2.31	9.49	.84	.10	.94	.404	.355	.759	2.515	3.274	.097	.048	.145	.077	.222
average (2)			68.73	5.53	25.86	31.29	1.97	.22	.02	2.21	15.69	17.89	1.11	1.33	2.44	10.20	.89	.08	.97	.353	354	.707	2.510	3.217	.114	.048	.162	.058	.220
2nd animal fore quarter																													
1973	chuck	fresh	70.71	4.85	24.62	29.47	1.68	.26	-.05	1.94	15.66	17.60	.89	1.24	2.13	8.76	.78	.20	.98	.310	.285	595	2.506	3.101	.097	.047	.144	.069	.213
1993	"	refrig	71.69	5.56	23.26	28.82	2.05	.21	.01	2.27	16.34	18.61	1.02	1.55	2.57	6.69	.72	.23	.95	.363	.325	.688	2.614	3.302	.125	.018	.143	.085	228
hind quarter																													
1969	loin	fresh	71.12	5.52	22.88	28.40	2.03	.18	.00	2.21	15.15	17.36	1.02	1.44	2.46	7.59	.85	.14	.99	.354	.329	.683	2.424	3.107	.101	.056	.157	.083	.240
1988	"	refrig	70.50	6.43	23.83	30.31	2.13	.22	.06	2.41	15.93	18.34	1.26	1.89	3.15	7.78	.87	.17	1.04	.385	405	.790	2.549	3.339	.134	.064	.198	017	215

Table No. III.

Chemical Composition of Raw Beef.

A comparison of Fresh and Refrigerated Cuts.

Calculated to Water free Basis.

Table III.

Lab.	Cut	Description	Dry Substance			Proteid						Organic Extractives			Fat	Ash			Nitrogen					Phosphorus				
						Soluble													Soluble					Soluble				
No.			Soluble	Insoluble	Total	coagulable	albumoses	peptones	Total	Insoluble	Total	nitrogenous	non-nitrogenous	Total		Soluble	Insoluble	Total	Proteid	non-proteid	Total	Insoluble	Total	inorganic	organic	Total	Insoluble	Total
			%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%
1st animal fore quarter																												
1927	rib	fresh	13.84	86.16	100.00	5.14	.44	.09	5.66	43.81	49.46	2.87	3.08	5.95	41.95	2.23	.41	2.64	.905	.920	1.825	7.609	8.534	.281	.122	.403	.160	.563
1957	"	refrig	13.46	86.54	100.00	5.19	.75	-.25	5.94	41.98	47.92	2.47	3.03	5.50	44.44	2.03	.42	2.44	.952	.794	1.746	6.713	8.459	.292	.119	.411	.128	.539
1929	plate	fresh	11.02	88.98	100.00	3.77	.44	-.44	4.21	37.82	42.03	2.29	2.63	4.91	50.84	1.92	.29	2.21	.673	.733	1.406	6.051	7.458	.203	.135	.338	.138	.476
1959	"	refrig	9.56	90.44	100.00	3.44	.50	-.35	3.94	35.94	39.88	1.86	2.38	4.24	54.00	1.38	.50	1.88	.627	.594	1.221	5.754	6.975	.241	.073	.314	.110	.424
1930	chuck	fresh	13.32	86.68	100.00	4.81	.57	.43	5.82	44.58	50.40	2.66	2.58	5.24	41.63	2.26	.46	2.72	.928	.857	1.785	7.138	8.923	.307	.086	.393	.198	.590
1960	"	refrig	14.70	85.30	100.00	5.22	1.13	-.44	6.35	47.29	53.64	2.66	3.22	5.88	37.63	2.50	.34	2.85	1.013	.848	1.861	7.570	9.431	.360	.078	.438	.185	.622
average ③		fresh	12.73	87.27	100.00	4.57	.48	.18	5.22	42.07	47.30	2.61	2.76	5.37	44.81	2.14	.38	2.52	.835	.837	1.672	6.733	8.405	.25	.114	.378	.132	.550
average ③		refrig	12.57	87.43	100.00	4.62	.79	.00	5.41	41.74	47.15	2.33	2.88	5.21	45.36	1.97	.42	2.39	.864	.745	1.609	6.679	8.288	.298	.090	.388	.140	.528
hind quarter																												
1924	round	fresh	20.29	79.71	100.00	9.25	.53	-1.23	9.78	56.89	66.67	3.73	3.73	7.46	22.22	3.06	.60	3.66	1.565	1.199	2.764	9.100	11.864	.345	.176	.521	.289	.809
1954	"	refrig	19.18	80.82	100.00	6.84	.77	.07	7.68	53.13	60.81	3.82	4.59	8.41	27.49	3.08	.20	3.29	1.227	1.227	2.454	8.505	10.959	.396	.174	.570	.184	.754
1926	loin	fresh	16.61	83.39	100.00	6.14	.57	.06	6.77	45.51	52.28	3.43	4.03	7.46	37.76	2.39	.12	2.51	1.083	1.098	2.180	7.283	9.463	.286	.134	.421	.215	.635
1956	"	refrig	16.18	83.82	100.00	5.77	.64	.03	6.41	47.12	53.55	3.25	3.92	7.16	36.40	2.58	.30	2.88	1.029	1.038	2.067	7.538	9.605	.334	.134	.468	.185	.653
average ②		fresh	18.45	82.55	100.00	7.70	.55	.02	8.27	51.21	59.48	3.58	3.88	7.46	29.99	2.73	.36	3.09	1.324	1.148	2.472	8.192	10.614	.316	.155	.471	.251	.722
average ②		refrig	17.68	82.32	100.00	6.31	.71	.04	7.06	50.12	57.18	3.54	4.25	7.79	31.95	2.83	.26	3.09	1.128	1.133	2.261	8.021	10.282	.365	.154	.519	.185	.704
2nd ~~animal~~ fore quarter																												
1973	chuck	fresh	16.46	83.54	100.00	5.70	.88	-.17	6.58	53.14	59.72	3.02	4.21	7.23	29.73	2.65	.68	3.33	1.052	.967	2.019	8.504	10.523	.329	.159	.489	.234	.723
1993	"	refrig	19.29	80.71	100.00	7.11	.73	.04	7.88	56.69	64.57	3.54	5.38	8.92	23.21	2.50	.80	3.30	1.259	1.128	2.387	9.070	11.457	.434	.062	.496	.295	.791
hind quarter																												
1969	loin	fresh	19.44	80.56	100.00	7.15	.63	.00	7.78	53.35	61.13	3.59	5.07	8.66	26.73	2.99	.50	3.49	1.246	1.158	2.405	8.538	10.940	.356	.197	.553	.292	.845
1938	"	refrig	21.21	78.79	100.00	7.03	.72	.20	7.95	52.56	60.51	4.16	6.23	10.39	25.67	2.87	.56	3.43	1.270	1.336	2.606	8.410	11.016	.442	.211	.653	.056	.709

Table No. IV.

Chemical Composition of Raw Beef.

A comparison of Fresh and Refrigerated Cuts.

Calculated to Water and Fat Free Basis.

Table IV.

Lab. No.	Cut	Description	Dry Substance			Proteid						Organic Extractives			Ash			Nitrogen					Phosphorus				
						Soluble				Insoluble	Total							Soluble			Insoluble	Total	Soluble			Insoluble	Total
			Soluble	Insoluble	Total	Coagulable	Albumoses	Peptones	Total			nitrogenous	non-nitrogenous	Total	Soluble	Insoluble	Total	Proteid	non-proteid	Total			Inorganic	organic	Total		
			%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%
1st animal fore quarter																											
1927	rib	fresh	23.84	76.16	100.00	8.85	.75	.15	9.75	75.46	85.21	4.95	5.29	10.24	3.85	.70	4.55	1.559	1.584	3.143	12.074	15.217	.485	.210	.695	.275	.970
1957	"	refrig	24.11	75.89	100.00	9.34	1.34	-.44	10.64	75.15	85.79	4.42	5.42	9.84	3.63	.74	4.37	1.705	1.421	3.126	12.018	15.144	.522	.214	.736	.228	.964
1929	plate	fresh	22.48	77.52	100.00	7.67	.90	-.90	8.57	76.94	85.51	4.66	5.34	10.00	3.91	.58	4.49	1.370	1.491	2.861	12.311	15.172	.412	.275	.687	.280	.967
1959	"	refrig	20.77	79.23	100.00	7.44	1.09	-.76	8.56	78.14	86.70	4.03	5.18	9.21	3.00	1.09	4.09	1.363	1.292	2.655	12.508	15.163	.523	.158	.681	.240	.921
1930	chuck	fresh	22.83	77.17	100.00	8.25	.98	.74	9.97	76.38	86.35	4.56	4.42	8.98	3.88	.78	4.66	1.590	1.468	3.058	12.229	15.287	.525	.147	.672	.440	1.112
1960	"	refrig	23.57	76.43	100.00	8.38	1.81	-.70	10.13	75.88	86.01	4.26	5.17	9.43	4.01	.55	4.56	1.625	1.359	2.984	12.136	15.120	.577	.125	.702	.296	.998
average (3)		fresh	23.05	76.95	100.00	8.26	.88	.29	9.43	76.26	85.69	4.72	5.02	9.74	3.88	.69	4.57	1.506	1.515	3.021	12.204	15.225	.474	.211	.685	.331	1.016
average (3)		refrig	22.82	77.18	100.00	8.39	1.41	-.02	9.78	76.39	86.17	4.24	5.25	9.49	3.55	.79	4.34	1.564	1.358	2.922	12.220	15.142	.541	.165	.706	.255	.961
hind quarter																											
1924	round	fresh	26.08	73.92	100.00	11.89	.68	-1.68	12.57	73.15	85.72	4.79	4.79	9.58	3.93	.77	4.70	2.012	1.541	3.553	11.700	15.253	.443	.226	.669	.371	1.039
1954	"	refrig	26.44	73.56	100.00	9.43	1.02	.10	10.59	73.28	83.87	5.27	6.33	11.60	4.25	.28	4.53	1.692	1.692	3.384	11.729	15.113	.545	.240	.785	.255	1.040
1926	loin	fresh	26.69	73.31	100.00	9.87	.91	.10	10.88	73.12	84.00	5.51	6.47	11.98	3.83	.19	4.02	1.740	1.763	3.503	11.701	15.204	.460	.216	.676	.345	1.021
1956	"	refrig	25.69	74.31	100.00	9.16	1.01	.05	10.21	74.80	85.01	5.16	6.22	11.38	4.10	.48	4.58	1.634	1.648	3.282	11.966	15.248	.530	.212	.742	.294	1.036
average (2)		fresh	26.39	73.61	100.00	10.88	.80	.05	11.73	73.13	84.86	5.15	5.63	10.78	3.88	.48	4.36	1.876	1.652	3.528	11.701	15.229	.452	.221	.673	.357	1.030
average (2)		refrig	26.07	73.93	100.00	9.30	1.01	.09	10.40	74.04	84.44	5.22	6.27	11.49	4.18	.38	4.56	1.663	1.670	3.333	11.848	15.181	.538	.226	.764	.274	1.038
2nd animal fore quarter																											
1973	chuck	fresh	23.42	76.58	100.00	8.11	1.25	-.24	9.36	75.62	84.98	4.30	5.99	10.29	3.77	.96	4.73	1.376	1.497	2.873	12.100	14.973	.468	.227	.695	.333	1.028
1993	"	refrig	25.12	74.88	100.00	9.27	.95	.05	10.26	73.83	84.09	4.60	7.01	11.61	3.25	1.04	4.29	1.640	1.469	3.109	11.812	14.921	.565	.081	.646	.384	1.030
hind quarter																											
1969	loin	fresh	26.52	73.48	100.00	9.75	.87	.00	10.62	72.80	83.42	4.90	6.92	11.82	4.08	.67	4.75	1.701	1.581	3.282	11.648	14.930	.485	.269	.754	.399	1.153
1988	"	refrig	28.54	71.46	100.00	9.45	.98	.26	10.70	70.70	81.40	5.59	8.39	13.98	3.86	.76	4.62	1.709	1.798	3.507	11.313	14.820	.595	.284	.879	.075	.954

Out of the seven cuts analyzed, four of the refrigerated cuts (1957, 1959,1954, and 1973) show a loss of water; one (1956), no change at all while two (1960 and 1993) both chuck cuts, show a gain over the corresponding fresh cuts in percentage of moisture content. 1959, rib cut, shows the greatest loss being 1.68% while 1960, chuck cut, shows the largest gain 1.67%. The average loss of moisture in the fore quarter of the first animal which hung for 19 days was 0.50% while in the hind quarter it was 0.53%. Disregarding the chuck cut, the average loss of the fore quarter was 1.60%. In the case of the second animal which hung for 43 days under the same conditions as the first, the refrigerated chuck cut (1973) shows a gain of 0.98% over the corresponding fresh cut. This gain, however, was much less than that of the chuck cut (1.67%) in the first animal which hung for less than half the time of the second. The refrigerated loin cut, on the other hand, shows a loss in moisture of .62% against the corresponding refrigerated cut of the first animal.

As the averages stand the meat which hung in cold storage for 19 days lost moisture while that which hung for 43 days did not. Considering the fact, however, that in both animals only the chuck cuts show an increase in moisture while the refrigerated loin cut in the second animal shows an increased loss of moisture over the same cut in the first animal, from the data at hand it is fair to say that meat loses moisture upon refrigeration.

There is an average increase in fat (table I) in the

the cold storage cuts but this is probably due to the difficulty of removing the fat from the refrigerated meat.

Tables II, III and IV as mentioned above give the analytical data in detail but as the composition of flesh in terms of the water and fat free substance gives the nutrients in a more strictly comparable form the remaining comparisons will be made on that basis.

DRY SUBSTANCE:

A loss in the soluble dry substance (see table IV, page 25) and a corresponding increase in the insoluble dry substance is to be found in the data for the refrigerated cuts in the first animal. In the second animal just the opposite is the case. A loss of .23% in the fore quarter cuts and .32% in the hind quarter cuts is shown in the first animal.. This exception is noticed, however, the rib and chuck cuts (1957 and 1930) show increases in soluble dry substance.

The data for the second animal shows the chuck cut (1993) to gain 1.70% soluble dry substance and the loin cut (1988), 2.02% against a gain of .74% and a loss of 1.00% in the corresponding cuts of the first animal. This would indicate that the increased period of refrigeration caused a gain in the soluble dry substance.

PROTEID:

The results for the coagulable proteid are irregular but on the whole the refrigerated cuts for both animals show a decrease from the fresh cuts. However, the rib (1957) and chuck (1960) of animal number one show an increase, likewise

the chuck cut (1973) in the second animal.

The albumoses show a marked and consistent gain throughout each cut in the first animal ranging from .91% to 1.01% (loin cuts) to .98% to 1.81% (chuck cuts. The increase in the two cuts of the second animal is not so evident, however, in fact the chuck cut (1993) shows a falling off from 1.25-.95% while the loin still shows a gain of .11%.

The peptones are minus quantities in most cases and show a loss from the fresh cuts.

The total soluble proteid shows a gain in both animals except in the round (1954) and loin (1956) cuts of the first animal where a decrease of 1.98% and .67% is found. The insoluble proteid of course gains in every cut at the expense of the soluble and loses where the soluble gains.

ORGANIC EXTRACTIVES:

The nitrogenous extractives show a marked decrease in all the refrigerated cuts of the first animal except the round cut (1954) This cut gives the increase of .48%. The second animal, however, shows an increase of .30% and .69% in the loin cut (1988).

The non-nitrogenous extractives on the other hand in every cut of both animals except the plate (1959) of the first which shows a decrease of .16%, gives an increase. The most marked increase is to be found in the chuck (1973) and loin (1988) where gains of 1.02% and 1.47% respectively are made. The total extractives show, on the average, a loss in the first

animal but a marked gain of 1.32% and 2.16% is found for the chuck and loin cuts of the second. As the flavor of meat is largely due to the organic extractives this should indicate that refrigeration would improve the flavor of meats.

ASH:

The soluble ash, on the average, shows no significant change in the cuts of the first animal but in the second a considerable decrease is evident. The chuck has 0.52% decrease and the loin a 0.22% decrease.

The insoluble ash being found by difference shows a slight average loss in the first animal and a gain in the second.

The total ash on the whole is slightly less in the refrigerated cuts.

NITROGEN:

Taking up the comparison for mitrogen, the soluble proteid nitrogen is found to be greater in the refrigerated cuts of the fore quarter of the first animal. This increase is evident in the second animal but a marked decrease is found in the head quarter of the first animal. On the whole, however, there is a decrease in both proteid and non-proteid nitrogen in the animal that hung for 19 days. The total soluble nitrogen in the fore quarter cuts shows an average loss of .099% while the hind quarter cuts give an average loss of .195%.

In the second animal which hung for 43 days, there is an increase in both proteid and non-proteid nitrogen at the expense of the insoluble proteid nitrogen. The chuck cut (1993)

shows an increase of 0.276% and the loin cut (1988) an increase of.008%. This might indicate that proteid bodies are built up during cold storage but the data is insufficient to warrant such a conclusion.

PHOSPHORUS:

The refrigerated cuts show an increase in the inorganic and soluble phosphorus. On the average there is no significant change in the organic phosphorus but the insoluble phosphorus shows a marked decrease in every cut except chuck cut (1993) in the second animal. The largest increase in inorganic phosphorus is .111% (plate cut 1959) and the lowest .037% (rib cut, 1957). The average increase in the fore quarter cuts is .067% while the hind quarter refrigerated cuts contained .086% more than the fresh cuts. The two cuts from the second animal show increases of .097% and .110%.

CONCLUSION.

The following facts concerning the relative composition of fresh and refrigerated beef are evident from the above analyses. The refrigerated cuts show a marked gain over the fresh cuts in percentage composition of albumoses, non-nitrogenous extractives, inorganic phosphorus and soluble phosphorus. A distinct loss of moisture is also shown.

Other changes have been noted in the above comparisons but the data in those cases is not sufficiently consistent throughout to warrant any conclusive statements.

Albumoses are modifications of albuminous bodies pro-

duced by enzyms considering the decided increase in albumoses in the refrigerated cuts the indications, therefore, are that these inorganized ferments are active in the meat during cold storage and convert some of the albuminous bodies in the flesh to albumoses.

It is a well known fact that the flavors of meat are largely due to the amount of meat bases or organic extractives present. The increase in non-nitrogenous organic extractives in the refrigerated cuts on these grounds would seem to indicate that cold storage for short periods of time tend to improve the flavor of meat. This, however, remains to be proved.

The most marked effect of refrigeration in this experiment is the effect upon the phosphorus content of meat. There is, unmistakably, a redistribution of the phosphorus. The amount of soluble phosphorus in the meat is increased by the conversion of some of the insoluble into the inorganic form.

Recapitulating, meat in cold storage suffers a loss of moisture by evaporation; it is preserved from the decay due to putrefactive bacteria whose action must be checked; the action of enzyms present, shown by the increased amount of albumoses present, is not checked; there are indications of improvement in flavor shown by the increase in non-nitrogenous organic extractives and a considerable amount of the insoluble phosphorus is converted into a soluble form.

I wish here to express my thanks to Dr. H. S. Grindley and Mr. A. D. Emmett for the advice and aid they have given me in the preparation of this thesis.

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